TOOLS AND MEASURES TO MEET THE ELECTRIC POWER DEMAND OF THE GAZA STRIP GOVERNORATES

Assad Abu-Jasser

Electrical Engineering Department - IUG, Palestine, ajasser@iugaza.edu.ps

ABSTRACT:

Load shedding or switching-off and switching-on of customers is a daily and common practice in the Gaza Strip governorates due to the high power shortage resulting from the imbalance between the power demand and the power supply. The power shortage is attributed to a number of factors ranging from a limited electric power supply, an ever increase in power demand, a high power loss in feeders and distribution grid, an absence of electric energy saving habits, and a political aspect. This paper presents a thorough evaluation of the current status of the electric power system in the Gaza Strip governorates and introduces a number of tools and measures that might lessen the power shortage to a relatively low value or even could secure the total electric power demand in the upcoming years. The main suggested tools and measures are the construction of the transmission grid, the interconnection with the regional electric power grid, the increase of imported power from neighboring countries, the expansion of the Gaza Power Generation Plant (GPGP). There are also other means such as rehabilitation of the electrical distribution grid, exploiting of renewable energy resources mainly solar and wind energies, and implementing of electric energy saving habits. The results have shown that significant reduction in the power shortage might be accomplished and that the power demand for the local community in the Gaza Strip governorates might also be secured in a relatively acceptable period of time.

KEYWORDS: Load shedding, interconnected power grids, rehabilitation of distribution grid, electric energy saving, and renewable energy

1. INTRODUCTION

Electric energy has become a vital commodity for mankind in all aspects of everyday life and the demand for this commodity is growing day after day. The average personal consumption of electric energy is considered one of the important criteria used in measuring the level of development and progress of nations. The recorded annual electric energy consumption of the Gaza Strip is 1234.014826 GWh in the year 2011 and this means that the average monthly electric energy consumption per capita is 57 kWh for that year [1] which is the lowest in the region and this figure is a way less than that of Jordan and Israel which are around 174.4425 kWh and 594.425 kWh respectively in the year 2008 [2, 3]. Perhaps this low average value of consumption in Gaza Strip is the result of the frequent cut-offs from the power grid.

An electric generation plant converts a prime source of energy such as coal, oil, and natural gas into mechanical energy and then into electric energy. The dependency on local prime resources of energy is one of the most crucial elements that affects the decision making and sovereignty of various nations away from external pressure that jeopardizes national interests. Therefore, securing permanent supplies of prime resources of energy are put at the top of the national priorities of all countries. In light of this fact, a generation power plant in the middle of the Gaza Strip has been constructed that can operate using diesel-oil or natural-gas as a prime source of energy. Unfortunately, the power generated does not meet the total power demand of the local community in the Gaza Strip Governorates. This implies that the Gaza Strip governorates still depend mainly on imported electric energy from neighboring countries. In additions, the Gaza power generation plant depends totally on a neighboring country for the supply of the prime resource of energy needed for its operation and this deepens the electricity problem. With the lack of sufficient electric power, disconnecting and connecting customers according to a preset timetable is the only way to continue providing quality power and sustain a power balance at the same time. Many schemes of disconnecting and connecting customers to the grid are available at hand to power system operators. It is the responsibility of the power utilities to find ways to minimize power disruptions and supply power equally in regard to the periods of time to their customers. The Local authorities have also a great obligation to make plans and find ways to satisfy the power demand of the inhabitants in their communities. This paper introduces a number of tools and measures that are available and could be employed to lessen the electric power shortage and even meet the whole electrical power demand of the Gaza Strip governorates.

The paper starts by presenting the electrical power needs and shortages of the Gaza Strip governorates and then the electrical power suppliers are introduced and at the end, the various tools and measures are presented and summarized.

2. Electric Power Demand and Shortage in the Gaza Strip Governorates

The number of inhabitants of the Gaza Strip governorates is estimated to be around 1,710,257 in July 2012 [4]. The electric power demand of these inhabitants in the same year is estimated at about 368 MW peak. Table (1) contains the estimated power demand and the corresponding power shortages as well as the percentage of the power shortage between the years 2010 and 2015 for the Gaza Strip governorates with the assumption that the Gaza Power Generation Plant is producing a power of 80 MW and the IEC supplies 120 MW and Egypt supplies 17 MW. Figure (1) shows these power estimates and the corresponding power shortages [5].

Table (1): Demand and Shortages between 2010 and 2015

Year	Demand Forecast (MW)	Power Shortage (MW)	Shortage Percentage %
2010	308	91	29.5
2011	٣٤٧	130	37.5
٢٠١٢	٣٦٨	151	41.0
٢٠١٣	٣٨٩	172	44.0
٢٠١٤	٤١٣	196	47.5
٢٠١٥	٤٣٨	221	50.5

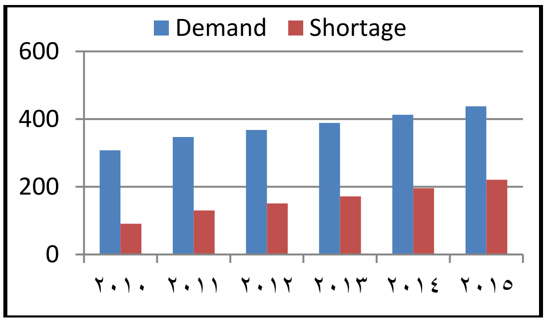


Figure (1): Demand and Shortage between 2010 and 2015

The values in Table (1) indicate that the power demand is constantly increasing from year to year at an approximate rage of 6.0-9.0% with an average of 7.5% yearly and at the same time the power shortages are increasing and in four years time this shortage will reach more than 50% of the available power in case that the power supply remains at the current amount. This also indicates that the current and the future electric power supply do not meet the needs for electricity of the inhabitants of the Gaza Strip governorates. Table (2) contains the categories and the number of customers for each category of the Gaza Strip governorates and their percentage, their energy consumptions and days/hours of operation as well as the average power needs for each category in the year 2011 [6]. The average power is calculated based on the working days and hours of operation for each category. For instance, the domestic average power demand is calculated based on 30 days per month and 24 hours of operation per day while the industrial average power demand is calculated based on 24 working days per month and 10 hours of operation per day. The shortage in electrical power is significant and in the year 2012 is expected to be around 41% and this means that 41percent of customers in the Gaza Strip governorates must be cut-off from the grid at every moment in order to satisfy a power balance between the supply and demand. As a consequence, load shedding is practiced on a daily basis to ensure such power balance. Many people resort to diesel- and gasoline-engine driven generation units to power their needs and these generation units are manufactured with different sizes and ratings spreading from hundreds of watts to thousands of kilowatts.

Table (2): 2011 customers, percentage, consumption KWh, operation days/hours and average power MW

Category	Domestic	Industrial	Commercial	Agriculture	Public	Total
Number	159442	4002	10869	3112	3364	180789
Percentage	70.06	5.40	7.09	2.89	14.56	100
Consumption	864501203	66674504	87535567	35688175	179615377	1234014826
Days/hours	30/24	24/10	24/12	30/10	24/8	30/14.5
Avg. Power	100.06	23.15	25.33	9.91	77.96	236.41

From this Table (2) it is clear that domestic and public sectors combined consume most of the power at about 75.3% of the available power. It is also believed that the domestic customers are the mostly harsh affected by the power shortages, while the public sector along with the remaining sectors are less affected and they usually turn to diesel-engine-driven generation units for electric energy supplies.

3. THE ELECTRIC POWER SUPPLY OF THE GAZA STRIP GOVERNORATE

The Gaza Strip governorates rely on three main suppliers of electric power: the Israeli Electric Power Company, the Gaza Power Generation Plant, and the Arab Republic of Egypt. Another source for electric power is the diesel- and gasoline-driven generation units that have spread in a noticeable pace in the last 3-4 years.

3.1 The Israeli Electric Company (IEC) Feeders

The Israeli Electric Company supplies a total of 120 MW over 10 three-phase feeders. Each is rated 12-MW at 22-kV. These feeders are spread across the line borders between the Gaza Strip and Israel. Figure (2) depicts the names and locations of these 10 feeders. The control room containing switches and measurements for each feeder is located near the border line and solely controlled by the IEC. The Palestinian side assumes the role of receiving whatever power is allowed to flow through these feeders and distribute it to the local community through the Gaza Electricity Distribution Company [7]. During power disruptions or malfunctions of such feeders that may take place from time to time, GEDCo maintenance crews were not able to get to the damaged locations to make repair or maintenance activities and this may continue for days and in many occasions the crews had to wait for weeks to get permissions to reach to the required sites. During such periods, the electric power shortages rise to values greater than those shown in Table (1). It is also worth mentioning that the IEC imposes a penalty on the Gaza Electric Distribution Company when the power factor falls below 92% and collected a sum of NIS445066.96 ($127161.99) in the year 2007. According to PENRA an average of NIS360000 ($100000) is collected annually due to this measure. This sum can be avoided if a proper capacitor banks are installed around the distribution grid at certain locations in order to reduce the losses and to keep the power factor greater than 0.92 of all feeders supplying power to the Gaza Strip distribution grid.

Figure (2): The Israeli Electric Company Power Feeders

3.2 The Gaza Power Generation Plant (GPGP)

Until the year 2002, the Israeli Electric Corporation was the only source of electricity to the local community in the Gaza Strip governorates. In June 18, 2002 A GT11 Simple Cycle Gas Turbine at the Gaza Power Generation Plant which was under construction in the heart of the Gaza Strip starts delivering for the first time ever a sum of 22.9 MW to the surrounding area.

Figure (3): Location and View of the Gaza Power Generation Plant

The generated power was supposed to be increased gradually reaching its maximum of 140 MW in March 15, 2004. However, only a sum of 80 MW of this capacity is effectively generated and fed to the distribution grid because a planned 220-kV transmission line is not constructed yet. The remaining demand is still covered by the Israeli Electric Corporation. Plans for interconnecting the still not constructed 220-kV transmission grid in the Palestinian territories with neighboring countries are scheduled in the future. Despite the power shortage, there are no plans in sight for expanding the generation capacity of power plant though the area designated for this plant is suitable for expansion up to a capacity of 560 MW. Figure (3) shows a view of the Gaza Power Generation Plant and its location on the map in the Nuseirat area in the middle of the Gaza Strip. The map shows the location of the generation plant along with the three substations and the corridor for the transmission grid. In the year 2004 and after a relatively long delay, the construction of the Gaza Generation Power Plant (GPGP) in the middle of the Gaza Strip is completed and the plant has commenced to supply electricity to the local community for the first time ever [8]. This plant is designed to operate using diesel-oil or natural-gas as a prime source of energy with a nominal power of 140 MW. Unfortunately this nominal power does not meet the total power demand of the local community in the Gaza Strip governorates. Moreover, the plant supplies only 80 MW of its 140 MW capacity due to the absence of high voltage overhead transmission lines. The construction of these lines (220-kV, double circuit) was supposed to be completed in the year 2004 along with the power plant. However, the political unrest hindered the completion of this project.

3.3 The Egyptian Feeders

A huge electric power shortage has resulted in the Gaza Strip governorates in the aftermath of the Israeli air-raid at the Gaza Power Generation Plant on 28 June, 2006. At that raid, the four power transformers at the GPGP site have been directly hit and completely destroyed and forced to go out of service leaving the electric power supplied by the GPGP to zero. Late that year, Egypt has managed to provide a 40-km, 22-kV overhead feeder to Rafah Governorate delivering 5 MW peak and late 2007 additional feeder delivering 12 MW has been connected to the distribution grid of Rafah governorate bringing the total power imported from Egypt to 17 MW.

3.4 Diesel- or Gasoline-Engine Driven Generation Units

As a result of practicing load shedding on a daily basis in the Gaza Strip governorates the residences have turned their attention to diesel- and gasoline-engine driven generation units to cover part of their needs for electricity. Unfortunately, there are neither credible nor accurate statistics available in regard to the numbers, specifications, and power ratings of these units. Nevertheless, it is estimated that 50-60% of the domestic customers are taking advantage of these units and the power taken from these units is estimated to be in the range of 40-50% of the power required for domestic application when they are disconnected from the grid during night load shedding periods [according to PENRA]. This amount of power is estimated at 13.62 MW (Domestic Customers Using Diesel- and Gasoline-Engine driven generation units 55% × Domestic Demand During Load Shedding 45% × Domestic Demand Percentage 42.3% × 130 MW Shortage).

(a) **(b)**

Figure (4): Standby Diesel-Engine-Driven Generation Units
(a) 2500 kVA unit (b) 5 kVA unit

However, industrial, commercial, and public customers such as factories, banks, shops, ministries, educational institutions, and hospitals have steady power supply during daytime and night power cut-offs. Figure (4) depicts such diesel-engine driven generation units. Figure 4 (a) shows a 2500 kVA unit that might be suitable for industrial installations, and hospitals while Figure 4 (b) shows a 5 kVA unit that might be adequate for commercial shops and homes.

4. THE PLANNED TRANSMISSION GRID FOR THE GAZA STRIP GOVERNORATES

The proposed transmission grid for the Palestinian territories is a 3-bus double circuit overhead transmission line and three substations. The West substation located at the Gaza Power Generation Plant with four power transformers each rated 22/220-kV, and 35 MW, making the total power rating at 140 MW which is the nominal power of the generation plant. The north substation is located east of the Gaza city at 12.4-km from the generation plant and contains two 3-winding transformers 220/160/22-kV with 120 MW. It is designated for future interconnection with the Israeli Electric Company through a 17-km long transmission line to deliver a sum of 120 MW to the Gaza strip replacing the ten feeders currently providing 120 MW of electric power to the Gaza Strip in stage one. The south substation is 7-km from the Egyptian border and 32.4-km transmission line connecting it to the north substation.

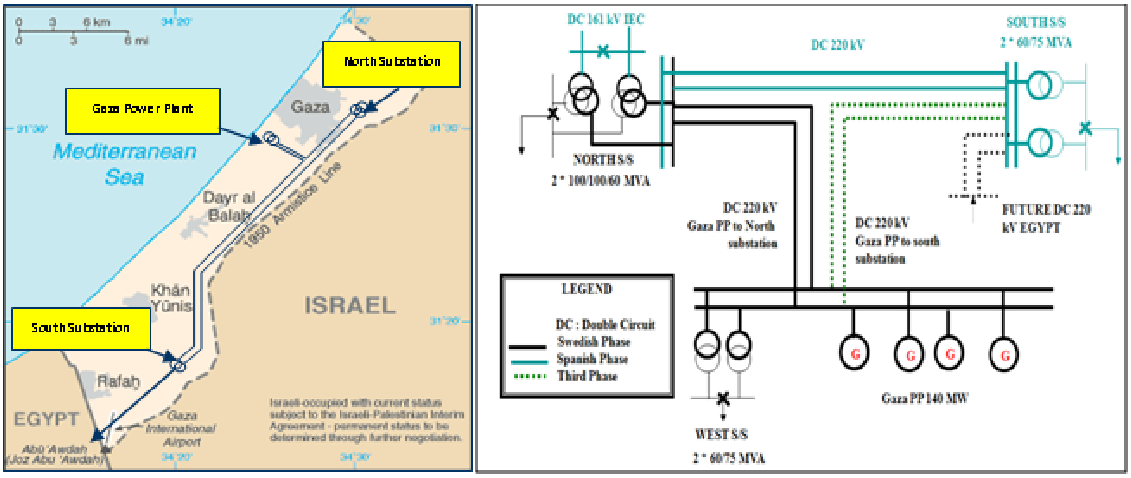


Figure (5): Planned Transmission Grid and its Corridor for the Gaza Strip Governorates

Two 220/22 kV transformers are located at this station. It is designated for future interconnection with the 220-kV Egyptian transmission network through a 50-km long transmission line inside the Egyptian territories. The suggested grid is to be completed in three phases as shown in the legend in the graph and the third phase was supposed to be completed simultaneously with the GPGP in 2004. Figure (5) illustrates the corridors and the single-line diagram of the planned transmission grid.

5. Methods of Securing Electric Power Demand

The demand for electric power is growing up steadily in the Gaza Strip and without any actions to secure this demand, electric power shortages will disturb and even paralyze all aspects of life in the Gaza Strip governorates in the upcoming years. Therefore, swift measures and methods that could help secure the demand for electric power of the inhabitants of the Gaza Strip governorates must be considered or at least consider actions that could help reduce the power shortages in a relatively short period of time. In the following, and in accordance with the urgent need for actions, a number of methods and measures are suggested.

5.1 Construction of the Transmission Grid

The absence of a transmission grid in the Gaza Governorates worsens the electric energy problem. The Gaza Power Generation Plant is not functioning at its 140-MW full capacity rather it is delivering a maximum of 80-MW which is a 60-MW short of its full capacity. This is because of the absence of a suitable transmission grid and the 22-kV distribution grid is not capable of carrying the full capacity of 140-MW. Therefore, true and effective efforts have to be exerted to start constructing a suitable transmission grid that would carry and transport the power needed. Only this way, the inhabitants of the Gaza Governorates could take advantage of the remaining 60-MW shortage of the Gaza Power Generation Plant and could benefit from the possibility of expanding the power generated locally and from imported power from neighboring countries when the transmission line is connected with regional power grid as planned. It should be noted that this needed grid should be designed to be adequate for future plans to expand the Gaza Power Generation Plant and for future intentions to interconnect with neighboring grids.

5.2 Increase of Imported Power from Neighboring Countries

In the absence of the 220-kV transmission grid and with the continued power shortage it is of great important to find feasible alternatives to meet the power demand of the Gaza Strip governorates. In the year 2012 an additional 150 MW power is needed in order to maintain a balance between demand and supply. Increasing the imported power from neighboring countries is an attractive option. However, the feeders supplying power to the Gaza Strip governorates are almost working at their limits whether they come from the Egyptian or the Israeli grids and any increase in their power delivery is out of question. Therefore, enlarging the size of the wires of the current feeders is essential to increase the power carrying capabilities of these feeders. The other option would be to construct new feeders capable of carrying the additional 150 MW needed. This however needs new delivery contracts between the supplier and the Gaza Electric Distribution Company.

5.3 Interconnecting with Electric Grids of Neighboring Countries

Interconnection between electric power grids allows the exchange of power from one grid to another and this ensures continuous power supply to customers. At the same time enhances system stability and increases reliability and guarantees economical operation of the whole grids. Usually interconnection between grids takes place at high voltage levels and at certain locations called interconnection substation. This means that the Gaza 220-kV transmission grid needs to be constructed in order to interconnect with neighboring grids. In the interconnection substations, special tools and equipment are installed and measurements are made. Even when the production of the GPGP is raised to its nominal value of 140 MW there will be a significant power shortage and thus, interconnection with neighboring grids might be an option to guarantee that the total power needs of the Gaza Strip governorates are completely covered. Figure (6) illustrates the suggested regional interconnections with the Egyptian and with the Israeli Electric Company power grid at the south and north substations respectively. In case these interconnections are carried out there would be no more need for the feeders currently supplying power to the Gaza Strip governorates where power is then fed to the 22-kV lines directly from the interconnection substations.

Figure (6): Suggested Regional Interconnections

5.4 Expanding the Gaza Power Generation Plant

When the decision was taken to construct the GPGP in the Nuseirat area in the middle of the Gaza Strip it was meant to be as a symbol of sovereignty besides supplying the local community with the power needed and interconnecting with neighboring grids. Many observers believe that the contract and prime fuel supply agreements have put unnecessary burden on the Palestinian authority budget. The first stage of the GPGP was completed in 2002 with a generation capacity of 140 MW. The land designated for the plant is enough and adequate for a total 560 MW generation units. Hence, it is suggested that additional 140 MW generation units to be urgently built bringing the total nominal power of the GPGP at 280 MW. It is believed that this additional stage could be completed in one year time if a decision is taken but it seems that political turbulences in the area have delayed plans for expanding of the GPGP and there are no indications that things will change in the upcoming future. Anyway, it is also necessary to work simultaneously on constructing suitable feeders capable of receiving and delivering the total generated power to the customers. The installation of the additional 140 MW generation units at the GPGP would reduce the power shortage in the Gaza Strip governorates and make this shortage insignificant. This measure however would ensure meeting the local community demand for power in the year 2012. Moreover, plans for the upcoming years have to be prepared and ready for additional expansion of the power generation capacity of the GPGP to reach 560 MW. This power capacity along with the construction of the 220-kV transmission grid would guarantee a secure and continuous supply of electric power to the Gaza residences up to the year 2020.

5.5 Rehabilitation of the Distribution Grid

The electric distribution grid receives power from transmission lines to distribute it over the customers connected to that grid. A properly designed distribution grid must ensure a continuous flow of the power demand to all customers at an acceptable voltage level and at almost constant frequency while keeping the losses as low as possible. The Gaza Strip distribution grid consists of three-phase overhead system of 22-kV bare-stranded-aluminum conductor (ACSR), pole-mounted distribution transformers with various power ratings, 0.4-kV bare-stranded-aluminum conductor (AAC), and 0.4-kV twisted copper conductor cables (ABC). Unfortunately, all these components operate under unbalanced conditions and highly overloaded. As a result, voltage drops below acceptable levels and the power losses are significantly high. The power loss in the distribution grid that supply electricity to the Gaza Strip inhabitants is calculated to be around 20% (19.4% in the IEC feeders and 20.28% in the GPGP feeders) of the power flowing in that grid and this percent exceeds all tolerable and acceptable levels [9].

Table (3): Power Savings under Existing Unbalanced Conditions

Feeder	Power Loss		Power Saving	Total Power Saving (feeders × one feeder saving)
	Before Rehabilitation	After Rehabilitation		
IEC (Baghdad)	1484 kW	834 kW	650 kW	10 × 650 = 6.5 MW
Power Plant (J4)	1959 kW	1111 kW	848 kW	8 × 848 = 6.784 MW
Total Power Saving in Gaza Strip Distribution Grid				13.284 MW

Injection of reactive power at designated locations into the distribution grid using capacitor banks would alter the reactive power flowing into the distribution grid (feeders, wires and cables) and would reduce the reactive component of the currents flowing into that grid [9]. This would raise the voltage levels at the customers' terminals, lessen the power losses in the grid, and if the capacitor banks are carefully chosen the power factor penalty imposed might be avoided. The amount of loss reduction and improvement in voltage levels achieved are remarkable [10]. Also, the size and type of wires and cables of the distribution grid are usually chosen to meet the power demand of the customers connected at a certain time. In most cases in the Gaza Strip governorates, the selection of these wires and cables does not account for the natural demand growth and this makes them not adequate to transport power some years later and causes the power loss in them to increase significantly. Proposed replacements of inadequate wires and cables on the 22-kV and 0.4-kV levels have led to a notable savings in the power loss [10]. A rehabilitation of the electric distribution grid in the Gaza governorates refers to balancing of the three-phase feeders, wires, and cables (equal loading), resizing of the inadequate wires and cables, and connecting of capacitor banks around the grid to inject reactive power into that grid. Table (3) contains the figures for the existing power losses in the distribution grid and the corresponding figures after grid rehabilitation as well as the saving in these losses due to rehabilitation. Implementing these collective measures on the distribution grid would accomplish a significant amount of savings in power loss, improve reasonably the voltage levels, and increase the power that can be delivered through the grid feeders, wires, and cables. Moreover, payback period for implementing such tools and measures is around 18 months [10].

5.6 Electric Energy Saving Measures

Electric energy saving refers to the Consumption of minimum electric energy to perform all jobs as efficient as possible without affecting services, production of commercial and industrial facilities and most of all convenience and normal life individuals. This means that no restrictions are imposed on the consumption of electric energy but restrictions are imposed on wasting any portion of it. There are abundant measures that can be implemented to save electric energy in domestic, office, commercial, industrial, and public applications [11, 12]. Saving electric energy is like earning money and it has an economical, social, an environmental, and a technical impact. Saving electric energy means less electric bill, and more power available to supply other customers. The electric energy consumption in the Gaza Strip Governorates in the year 2011 amounted to 1234014826 kWh and according to PENRA and GEDCo; it is strongly believed that implementing electric energy saving measures would reduce the electric energy consumption in the range of 15-20%. To highlight the significance of electric energy saving, the data of the year 2011 is used. In that year an average reduction of 15% in electric energy consumption would mean a yearly saving of 185102224 kWh and this corresponds to an average power of 21.42 MW while a 20% reduction would mean a yearly saving of 246802965 kWh that corresponds to an average power of 28.56 MW.

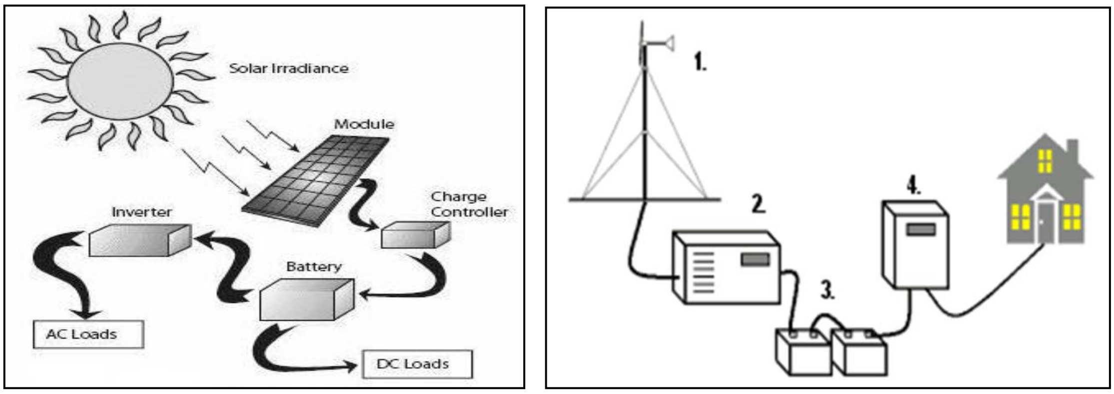
5.7 Area Generation Units

Diesel-engine driven generation units come with different sizes and power ratings and units up to 2500 kVA are manufactured by leading companies and are available in the market. Areas experiencing power cut-off periods may take advantage of such generation units. This approach is being adopted in some countries in the surrounding regions. Lebanon and Syria are examples of these countries. The generation units could be operated by local authorities or by qualified private investors. Either way, units' ratings, location, control, fuel supply arrangement, pricing need to be regulated and supervised by local authorities. As a start, such approach may be adopted in mostly hit areas by the power cut-off and gradually it can be adopted in other areas. A coverage of 25% of the power shortage as a start means that area generation units would secure more than 37.5 MW in the year 2012. For this purpose 20 generation units would be needed with the assumption that each unit is 2500-kVA and operate at 80% power factor.

5.8 Utilization of Renewable Energy

The geographical location of the Gaza Strip at 31° 25′ 0”N and 34° 20′ 0”E makes it a relatively sun-rich region with an annual solar irradiance of about 2000 kWh/m^2 [13] and its coastal location makes it experience an average annual wind speed of 10.14 km/hour (2.82 m/s) [14]. According to the locally recorded figures, the highest wind speed ever reached is 60 km/hour in winter. This implies that the utilization of solar and wind energy would be feasible and efficient enough for domestic, commercial, public and industrial applications. With the high electric power shortages at the Gaza Strip governorates, it seems that solar and wind energy systems are attractive means to power some applications in various areas in the Gaza Strip. Turning to exploiting of solar and wind energies as main or even as standby sources of power will help ease the pressure on the distribution grid and will make more power available to the utility grid to supply more customers.

Photovoltaic systems are classified according to how the system components are connected to other power sources such as stand-alone (SA) and utility-interactive (UI) systems. A stand-alone system is designed to operate independent of the electric utility grid, and is generally designed and sized to supply certain dc-/ac-electrical loads. However, in utility grid connection or sometimes called utility-interactive systems, power is brought in from the grid to supplement the system output when needed, and sold back to the utility when the photovoltaic modules' output exceeds the power demand.



(a) **(b)**

Figure (7): Stand-Alone Solar and Wind Energy Systems
(b) Solar Energy System (b) Wind Energy System

Wind energy systems transform the kinetic energy of the wind into mechanical or electrical energy that can be harnessed for practical use. Wind electric turbines generate electricity for homes and businesses and in some countries for sale to utilities. As a rule, an annual average wind speed equals or greater than four meters per second (2.5 m/s) or 9 km/h is required for small wind electric turbines [15]. Modern wind turbines have an availability of more than 98% and higher than most other types of energy systems. Figure (7) depicts schematic diagrams of stand-alone solar and wind energy systems. The components of the two systems are identical except for the source of energy. Figure 7 (a) shows a schematic diagram of a stand-alone solar energy system while Figure 7 (b) shows a stand-alone wind energy system. The cost to build such systems is still relatively high. For instance the cost to build a stand-alone solar system for a home that requires an average daily energy of 4.5 kWh is $18320 [16] while the cost to build a stand-alone wind system for the same home is $17798 [17]. The installation cost and payback periods of solar- and wind-energy systems are still relatively high and long and here comes the role of the local authorities in endorsing rules and regulations to encourage people to turn to such systems. For instance, custom and tax exemptions in addition to technical assistance and subsidizing the components used in these systems could make people think of adopting such systems as alternatives for energy supplies. An installation of 10-MW renewable energy systems that constitute around 3% of the total power demand in the year 2012 would be a good start.

6. SUMMARY OF TOOLS AND MEASURES

Securing the electric power demand of the Gaza Strip governorates maybe accomplished through a variety of tools and measures according to feasibility and estimated periods needed to implement such tools and measures. Table (4) contains a summary of these suggested tools and measures that can be employed.

Table (4) Summary of Tools and Measures, Secured Power (MW), and Estimated Period (Months)

Tools and Measure	Transmission Grid Construction	Increasing Imported Power	Power Plant Expansion	Regional Grid Connection	Distribution Grid Rehabilitation	Energy Saving Measures	Regional Generation Units	Renewable Energy Systems
Secured Power	60	120 - 150	140 - 280	unlimited	13.3	25 - 30	40 - 60	10
Estimated Period	18-24	6 - 9	24 - 30	24 - 30	6 - 9	3 - 6	6 - 9	9 - 12

It should be noted that it is possible to combine various tools and measures simultaneously. For example, electric energy saving measures, rehabilitation of the distributed grid, and adopting renewable energy systems might be implemented simultaneously and these measures could secure around 40 MW of power in an average period of time of 15 months. Other combinations are also available and it is up to the local authorities to choose from. Some tools could alone meet the total power demand such as expanding the Gaza Power Generation Plant and the Regional Grid Interconnection.

The study has been conducted in the years 2011/2012 and completed in April 2012. Therefore, some of the figures and numbers mentioned or listed in the various sections and paragraphs may vary as time passes by.

7. CONCLUSION

The power supply to the Gaza Strip governorates is limited while the power demand is growing with an annual average of 7.5% and also the power loss in the distribution grid exceeds all allowable and tolerable figures. Significant power shortages are the direct consequences and this forces the electric distribution company to practice load shedding in a regular basis and this harshly affects all aspects of life of the local community. A large number of the local community has turned to the use of diesel- and gasoline-driven generation units to cover their needs during the cut-off periods. The mostly affected customers by the power cut-offs are the domestic users as they constitute around 70% of the total customers and because around 50% of these domestic customers do turn to other alternatives to meet their demands while almost all other customers' categories satisfy their needs using diesel- and gasoline-driven generation units.

A number of tools and tools/measures have been proposed in this study and some of tools/measures might significantly help reducing the power shortages and others could even ensure a total coverage of the community needs. Simultaneous implementations of some of these tools/measures are also possible and each combination could secure various and significant amount of power within different periods of time varying from 6 to 18 months. Some of the tools could alone secure the total power demand of the local community such as expanding the capacity of the Gaza power generation plant and the regional interconnection and this could be accomplished within 2-3 years. The decision is left the local authorities to select/combine adequate tools/measures.

Finally, it should be mentioned that the political status resulted in the aftermath of the turn of events in the year 2007 in the Gaza Strip has an impact on the electricity problem. This element has hindered in many occasions and still hinders the start of implementing some if not most of the tools/measures that needed and aim at easing or solving the difficulties resulting from the electric power shortage in the Gaza Strip governorates.

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